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Manual of Instructions

Model 2470 2470/350

Magnet Charger

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Radio Frequency LABORATORIES, INC.
Boonton, New Jersey, U. S. A.

Designers and Manufacturers of Electronic Equipment since 1922

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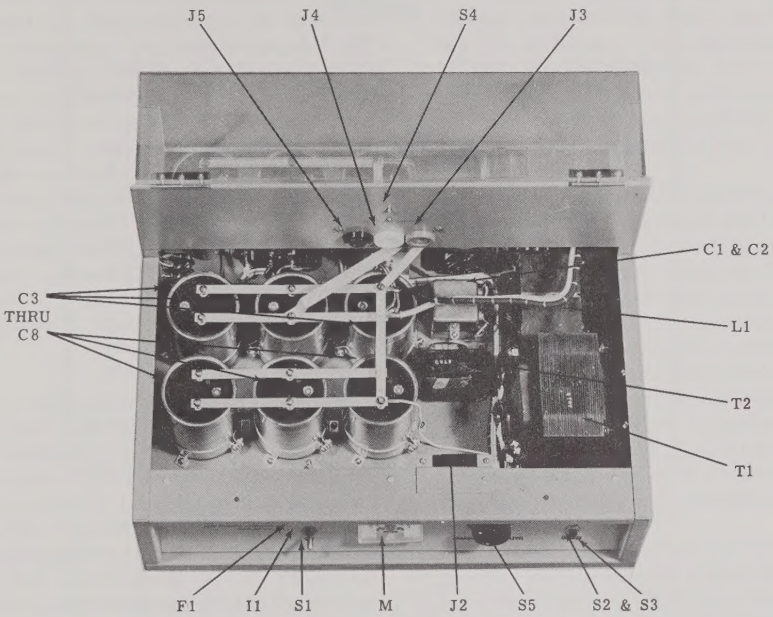
Description



Top View of Model 2470 Magnet Charger with Cover lifted.

The Models 2470 and 2470-350 are low voltage, high capacity impulse type magnet chargers. They have been designed to provide the maximum versitility and flexibility attainable in an equipment of this type. The complete unit is enclosed in a cabinet measuring 20 inches wide by 14 inches high by 16 inches deep. The work table area measures 11 inches by 20 inches. A hinged plexiglass hood over the work table is electrically interlocked and provides positive operator protection.

The Model 2470 incorporates a capacitor bank of 20,000 μF operating at a maximum emf of 150 volts with a resultant energy storage of 225 watt-seconds (joules). The applied voltage level can be varied from 35 to 150 volts in seven steps. This energy will saturate most configurations of Alnico V magnets up to $2\frac{1}{2}$ lbs.

The charging energy can be doubled to 450 watt-seconds by adding a Model 2500 Booster unit. The Model 2500 Booster unit is basically a 20,000 μF capacitor bank which is connected to the Model 2470 via a heavy duty connecting cable 48 inches long. This unit is equipped with cable receptacles to fit the Model 2470 only.

The Model 2470-350 operates at a maximum emf of 350 volts, adjustable from 60 volts in seven steps. The energy storage of the 7200 μF capacitor bank of 350 volts is 440 watt-seconds. This is sufficient to saturate about 4 lbs. of Alnico V and many core-type indicating meters completely assembled in their cases. It will saturate barium ferrite, cobalt platinum and certain sizes of Lodex or Alnico VIII.

The charging energy may be increased to 880 watt-seconds by connecting the Model 2500-350 Booster unit. The connecting of the additional 7200 μF capacitor bank is acheived by using a heavy duty cable 48 inches long having receptacles which fit the Model 2470-350 only.

The control panel, located just beneath the work table, incorporates the equipment on-off switch, protective fuse, pilot lamp, voltage level control, voltage level indicating meter, energizing control and the charging control. Heavy duty, recessed plug-in connectors are provided at the rear of the work table to facilitate changing fixture connections. A precision, non-inductive shunt is built into the charging circuit to permit measurement of the peak magnetizing current applied to the charging fixture, using an external sweep oscilloscope (not provided).

The equipment weighs about 75 pounds and operates from 115 or 230 volts at line frequencies of 50 or 60 Hz. Current consumption is about 7 amperes at 115 volts.

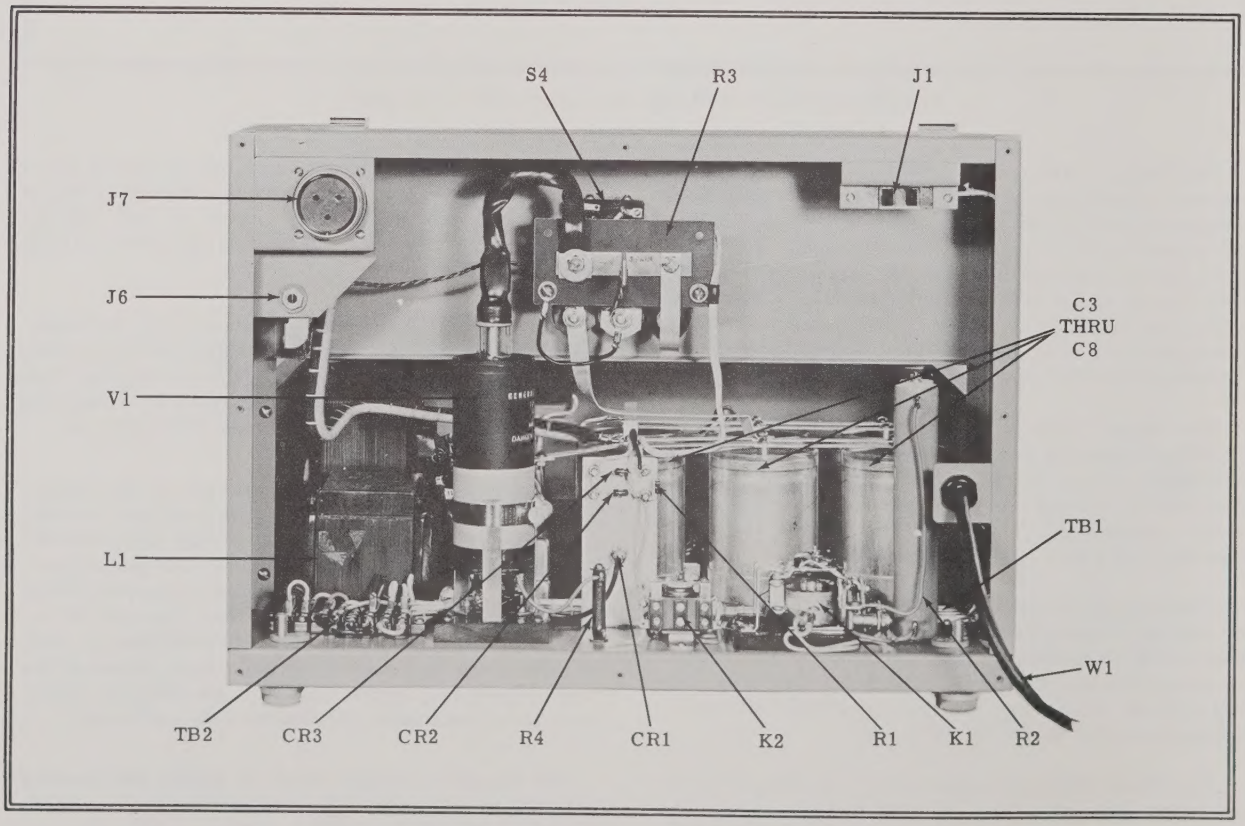
Theory of Operation

The Models 2470 and 2470-350 basically consist of a charging voltage transformer (T1), current limiting choke (L1), power rectifier (CR1 for 2470-CR1 and CR2 for 2470-350), charging voltage level selector (S5), ignitor supply consisting of transformer (T2), capacitors (C1 and C2), rectifiers (CR2 and CR3 for 2470-CR3 and CR4 for 2470-350), bleeder resistor (R1), energy storage capacitor bank (C3 thru C8, ignitron, control relays (K1 and K2), energize control (S2) and charging control (S3).

The voltage level applied to the capacitor bank is determined by the setting of the voltage level switch. Peak current during the charging of the capacitor bank is limited to approximately 15 amperes. Application of power to the charging voltage transformer and to the ignitor element of the ignitron is controlled by the interlocking relays which in turn are actuated by the energize and charge push-button keys. A series of protective interlock circuits are provided which prevent operation of the equipment if the work table hood is raised or if the work table or rear cover are removed for servicing. The circuitry not only locks out operation but inserts a bleeder resistor across the capacitor bank to insure positive discharge of energy in the capacitors.

In operation with all interlock circuits closed, pushing the ENERGIZE key activates relay K1. Pressure need only be momentary, since a holding contact on the relay maintains current through the coil. A second contact applies power to the primary of the charging voltage transformer T1. A third contact opens the bleeder resistor circuit R2 allowing the capacitor bank C3 through C8 to build up. The holding contact, and therefore the relay coil current, is interlocked through the ignition relay K2. When the CHARGE key is momentarily pressed, relay K2 closes, momentarily causing loss of current through relay K1 and allowing that relay to open. Simultaneously, the ignitor circuit is closed, and energy from capacitor C2 is applied to the ignitor through current limiting resistor R4. The stored energy from the capacitor bank C3 through C8 is conducted through the ignitron and through the connectors J3 and J5 to the charging fixture. Shunt R3 is a four-terminal resistor in series with the charging fixture. The voltage drop across the shunt is proportional to the current flowing through it.

Hood interlock S4 is connected in series with the holding circuit of control relay K1. Opening of the protective hood prevents energization of either relay and should the equipment be energized prior to opening of the hood, will cause the control relay K1 to drop out thus discharging the capacitor bank through bleeder resistor R2. Work table interlock P3 and rear cover interlock P2 are connected in series with the line power source and opening of either interlock will cause complete de-energization of the equipment.



Rear View of Model 2470 Magnet Charger.

Maintenance

CAUTION

Should it become necessary to service the Model 2470 or 2470-350 certain precautions should be taken to ensure personnel safety. Be certain that all voltage is removed from the storage capacitor bank and from any other capacitor in the equipment. This may be accomplished by placing a 50-ohm, 100-watt resistor across the terminals of the capacitor until all residual emf in the capacitor is discharged. The resistor should be fastened to the end of a bakelite rod approximately ten inches long. Placement of the resistor across a capacitor should be made by means of the rod. Where voltage measurements in the equipment must be made, always make the voltmeter connection with power removed from the equipment; then apply power and read the emf.

Some possible failures with appropriate remedies are:

Equipment completely inoperative - pilot lamp fails to glow. This condition may be caused by a defective fuse (F1), faulty ON-OFF switch (S1) or by open interlock circuits (P2 or P3).

Pilot lamp lights but pressing ENERGIZE key does not result in voltage indication or in sound of control relay pulling in. This generally indicates a faulty ENERGIZE switch, an open coil in control relay K1 (coil resistance is nominally 1250 ohms) or in poor contact through the holding circuit associated with the appropriate contact on relay K2.

Pilot lamp lights and control relay K1 pulls in when ENERGIZE key is pressed but no voltage is indicated on the panel meter. This may be due to poor contact in either of the relays, a defective power rectifier CR1, open circuit in transformer T1 or in a defective meter. Relay K1 should stay locked in after the ENERGIZE key is released. Failure of the relay to stay closed usually indicates an open circuit in the relay holding circuitry. NOTE: pressing of the CHARGE key should cause the control relay K1 to open and stay open until the ENERGIZE key is again pressed.

Meter indicates voltage present on capacitor bank, but pressing CHARGE key does not cause emf level to drop immediately and does not result in an impulse through the charging fixture. This can usually be traced to an open circuit in the charging fixture or a defective ignitron. The ignitrons used will generally have a life of many years. If pressing the CHARGE key does not cause the ignitron relay K2 to close, an open relay coil in K2 may be responsible. Coil resistance is nominally 1250 ohms. Loss of ignitor emf can also cause this condition. The potential across resistor R1 should be approximately 600 volts. Lack of emf at this point can be caused by a defective diode (CR2 or CR3 in the 2470, CR3 or CR4 in the 2470-350), a shorted capacitor (C2) an open capacitor (C1) or a defective transformer (T2).

Applications Data

The application data given on the following pages may be used as a guide to fixture design for charging magnets of various configurations. The red arrows denote the charging current path and the green arrows show the magnetizing flux configuration. For clarity in the illustrations only a few conductor turns are shown. The number of turns required depends upon the magnet size; as many turns as possible should generally be used.

Operation

CAUTION

The voltage used in the Models 2470 & 2470-350 though of low amplitude are dangerous due to the low source impedance. Therefore extreme caution should be used. Do not attempt to defeat the safety interlocks. Use the safety hood at all times unless the fixture design precludes the necessity for its use. Be sure that all charging fixture connections and plugs are tight, since the extremely high currents involved in the charging circuit can vaporize a poor connection, with resultant spattering of melted copper.

The Models 2470 and 2470-350 magnet chargers are normally shipped for operation at 115 volts, 50/60 Hz unless tagged otherwise. Three heavy duty plug-in connectors are included to facilitate attaching charging fixtures. It is recommended that fixtures being used have an impedance high enough to provide a maximum charging current of 1000 amperes. Current higher than this may possibly damage the ignitron. Fixtures of higher impedances (lower charging current) can be used and, in many cases, are desirable since they enable relatively long pulse length magnetization discharges. See Application Data Section for details of fixture design.

To operate, raise the plexiglass safety hood and allow it to rest on the top rear of the Charger. Connect the charging conductor or fixture into the red and black jacks on the charging panel using the plugs supplied. Close the plexiglass hood. The hood actuates a safety interlock; the Charger will not operate until the hood is closed. If a three-wire to two-wire adapter is used, be sure that the flexible green lead is grounded to the power line conduit or BX cable box. Place the CHARGING VOLTAGE LEVEL switch to its number 1 position. Place the ON-OFF toggle switch to ON. The neon pilot lamp adjacent to switch will glow. Momentarily press the ENERGIZE key; there will be an audible sound as the control relay in the Model 2470 is energized and the meter located on the control panel will indicate approximately 30 volts (approx. 50 volts for 2470-350). Increase the CHARGING VOLTAGE LEVEL control to its full clockwise position (number 7). The indicated voltage will rise to a maximum of 150 volts in the 2470 and 350 volts in the 2470-350. The full emf will be realized only under high line voltage conditions (approximately 125 volts). An indication of charging voltage of between 140 to 150 volts in the 2470 and from 330 to 350 volts in the 2470-350 is satisfactory.

Momentarily press the CHARGE key. There should be an audible thump in the charging fixture and the charging voltage should drop to near zero (Note: there may be a slight residual of 5 or 10 volts). If a charging conductor is used the wire may jump when the pulse is applied. Momentarily press the ENERGIZE key again. Note the time required for the equipment to reach full charge. The time required will depend upon condition and temperature of the energy storage capacitors, but ten seconds may be considered normal.

Any charging voltage level may be used providing it satisfactorily saturates the magnet being charged. Usually no more than two or three pulses are required and, in most cases, one charging pulse is sufficient.

The built-in shunt supplied with these chargers allow the measurement of both the peak current through the charging fixture and the length of the charging pulse. The shunt is connected to a triggered sweep oscilloscope by means of a twisted pair of leads which connect to the tip and ring of the three terminal plug (P4) provided with the equipment. The sensitivity of the shunt is nominally 3.5 millivolts per ampere; however, the actual calibration is marked on the shunt as well as the rear panel of the charger.

The white jack on the charging panel is connected to the case ground of the charger. This connection is used to ground any metal used in the fabrication of a charging fixture for maximum operator protection.

230-VOLT OPERATION

To operate from 230 volts, 50/60 cycles, the following changes must be made. These are made at the factory if ordered for 230-volts operation.

1. Remove rear cover and locate terminal board TB2. This lies at lower left side of chassis as viewed from rear.
2. Remove jumpers between 1 and 2, 3 and 4, 5 and 6, and 7 and 8.
3. Place jumpers between 1 and 4, and 6 and 7. (Jumpers between 3 and 5 remains in place).
4. Check wiring changes after completion against the schematic diagram. Replace rear cover.
5. In the Model 2470 change fuse F1 from 8 amp slo-blo to 5 amp slo-blo. In the Model 2470-350 change fuse F1 from 10 amp slo-blo to 5 amp slo-blo. Change connector P1 to 230V type. (See table of Replaceable Parts).

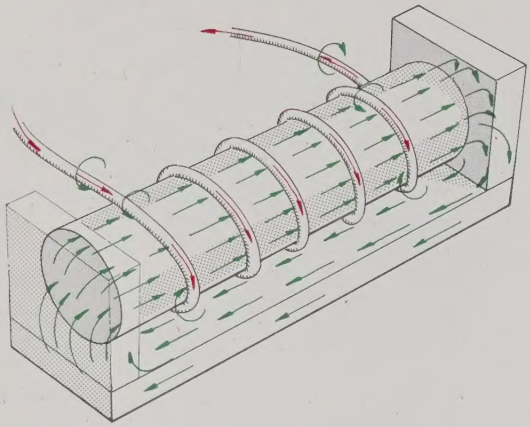


Figure 1.

Bar and Rod Magnets.

Bar and rod magnets are charged in a solenoidal configuration as shown in Figure 1. The charging winding may be wound directly on the magnet using well insulated wire. Where large quantities of bars are to be charged it is advisable to fabricate a fixture made from bakelite tubing, the I. D. of the tubing being large enough to accept the magnet. The charging winding is then wound on the O. D. of the tubing and the magnet inserted into the tube for magnetization. In many cases a return path as shown in the drawing will not be required. This can be determined by tests. Whether the return path is needed or not depends upon the length to diameter ratio of the magnet and the volume of material being charged.

Short Cylindrical Magnets and Assemblies.

This type structure is charged most efficiently in a short solenoidal fixture as shown. The winding may consist of fifty to two hundred turns of number 14 or 16 enamelled wire. The number of turns is not critical, but a greater number of turns results in a longer pulse length. The pulse length may be of some importance when charging structures incorporating large amounts of material such as aluminum. Materials of this type tend to develop eddy currents in a changing magnetic field and the eddy currents oppose the magnetizing field. When the magnetizing field has an impulse of sufficient duration the eddy currents decay before maximum magnetizing field is reached and are therefore not detrimental in a practical sense. In many cases the iron return paths shown on the top and bottom of the charging coil are not required. This depends on the particular magnetic structure being charged and can be determined by experimentation. Some of the structures which utilize this charging technique are loudspeaker assemblies, accelerometers, core magnet meter assemblies and door latch magnets.

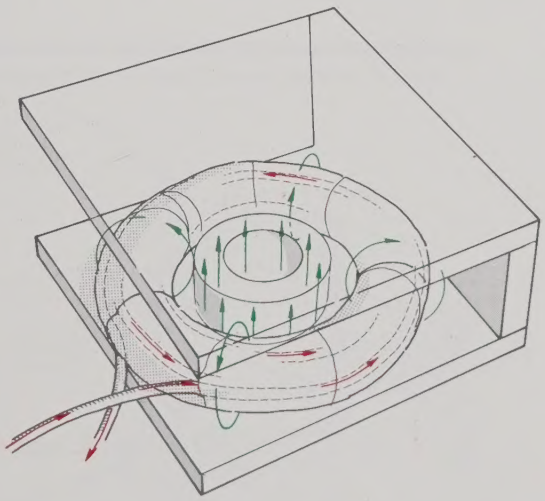


Figure 2.

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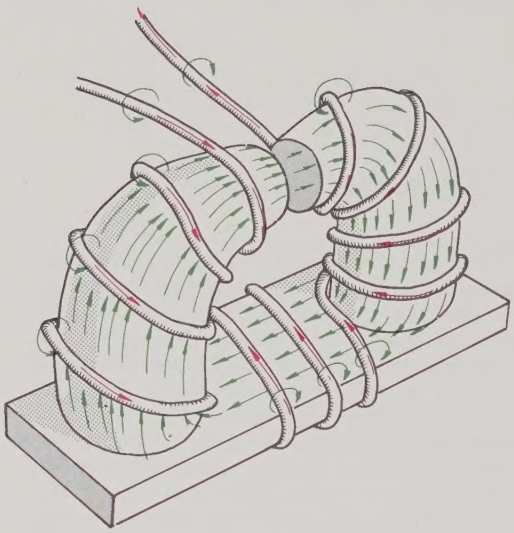

Figure 3.

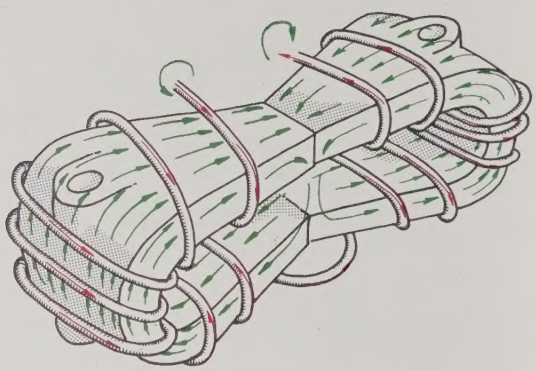

Figure 4.

Magnetron Magnets.

Two types of magnetron magnets are in general use at this time; the so called "horn magnet" as shown in Figure 3 and the double-U configuration shown in Figure 4. In general between 15 and 30 turns of well insulated number 10 wire will suffice as a charging fixture. In some cases it may be necessary to provide a keeper in the magnetic gap to insure full saturation of the assembly. This technique also allows the magnetization of the assembly with the magnetron tube in place in some instances.

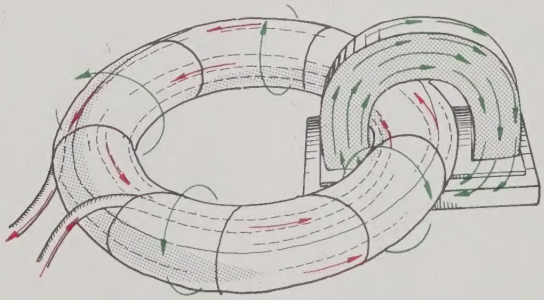

Figure 5.

U-Shaped and C-Shaped Magnets.

U-Shaped and C-Shaped magnets may be charged using a coil as shown in Figure 5 for relatively small magnets. For large magnets it may be necessary in many cases to wind the magnet with a number of turns of insulated wire, similar to the technique used in magnetization of the "horn magnet" shown in Figure 3. The coil technique allows magnetization of a number of magnets at one time and is a faster operation compared to winding individual magnets with turns of wire. The drawing shows a steel return path under the coil; however, this may not be required in all cases. The coil can consist of between 20 and 200 turns of number 14 enamelled copper wire.

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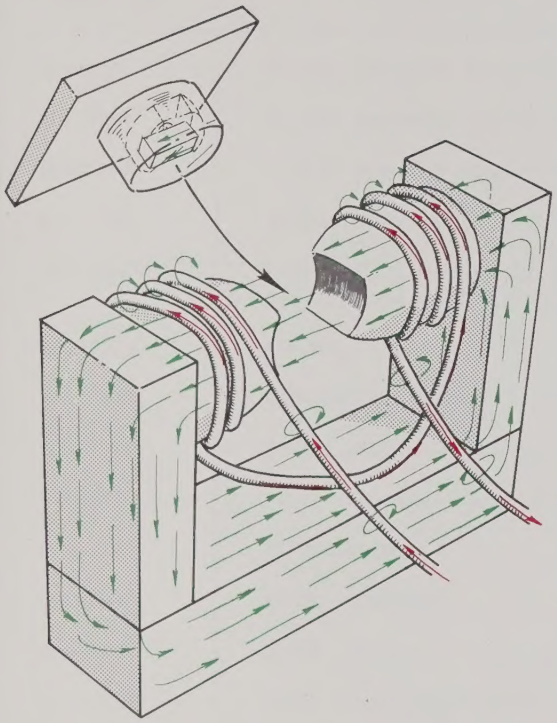

Figure 6.

Yoke Type Fixture for Magnetization of Assembled Indicating Meters.

The yoke shown in Figure 6 can, in many cases, fully saturate direct current meters of the D'Arsonval type. The magnet structure must incorporate a magnet of the straight bar type rather than a curved C or U-shaped element, since the applied magnetic field between the pole pieces is, for all practical purposes, straight. The fixture consists of an adjustable C-shaped iron structure incorporating two coils. Each coil should consist of approximately 100 turns of number 14 enamelled copper wire. The coils are connected so they aid each other magnetically as shown in the drawing. This type of structure can also be applied to other uses such as magnetization of bar and rod magnets and assemblies incorporating bar magnets.

Multi-Pole Magnetization.

The type of fixture shown in Figure 7 is used for magnetization of multi-pole rotors such as those used in tachometer generators. The assembly described is a four-pole unit; however, any number of poles from two to twenty or more can be magnetized. The wire size and spacing are determined by the configuration of the rotor.

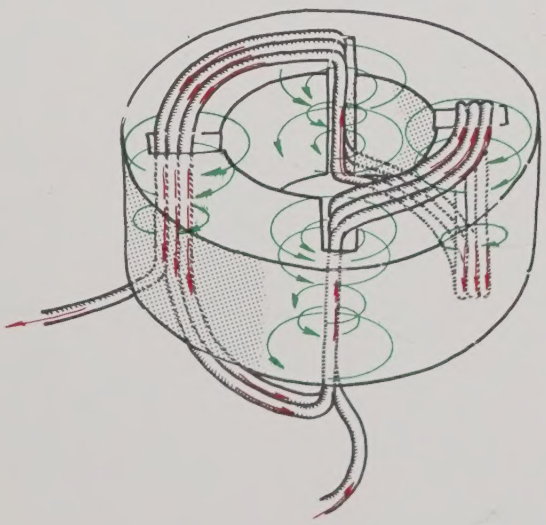

Figure 7.

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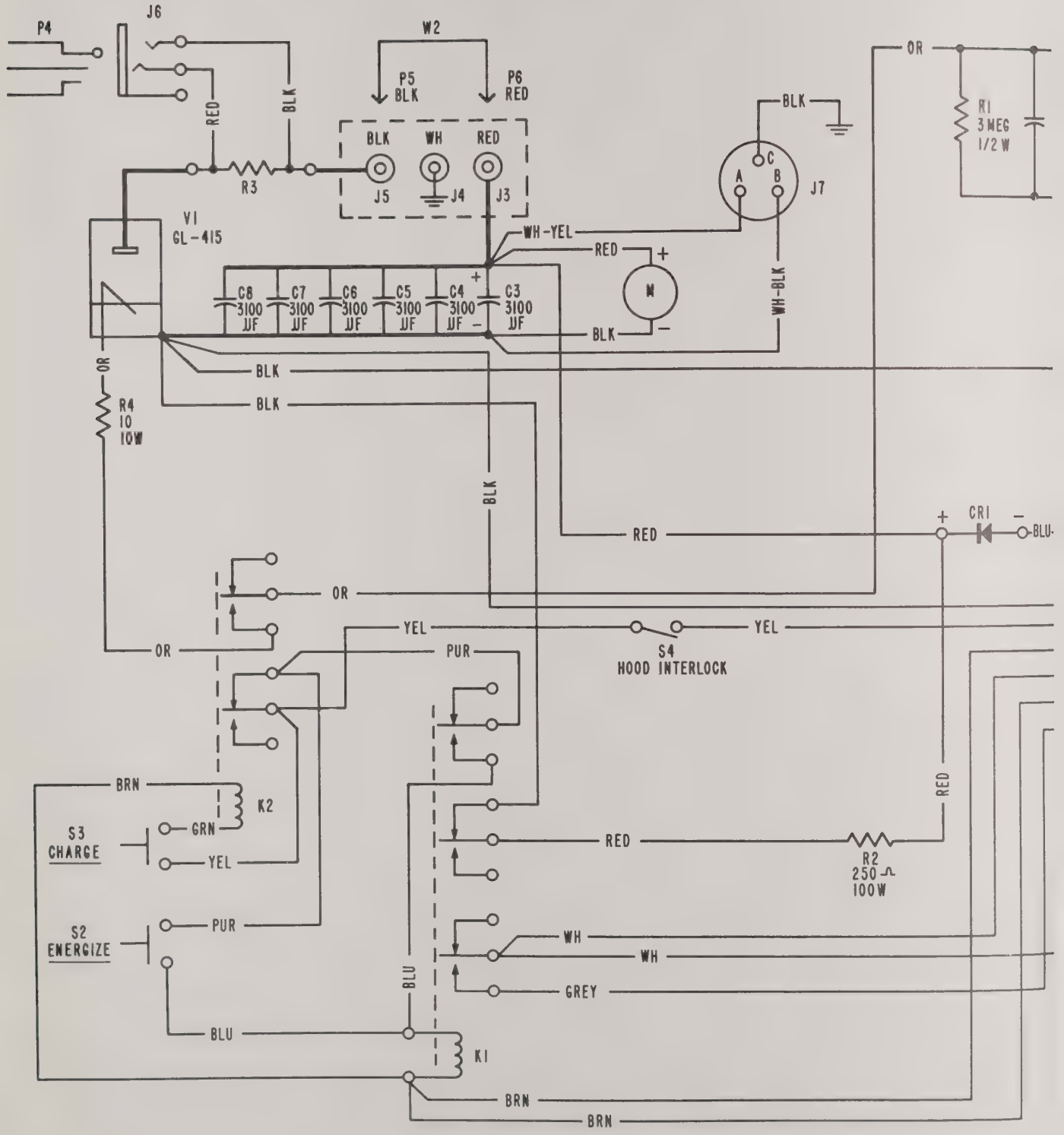
TABLE OF REPLACEABLE PARTS 2470

RFL PART NO.	NAME OF PART AND DESCRIPTION	DIAGRAM SYMBOL
HA-6487	BLOCK, terminal: 8-terminal.	TB2
HA-9412	BLOCK, terminal: 3-terminal.	TB1
HA-7750	CABLE, power: 3-conductor # 16, .360 dia. rubber sheath.	W1
HA-1259	CAPACITOR, fixed: oil-filled paper; 2 μF, 600 V.	C1, C2
HA-17315	CAPACITOR, electrolytic: aluminum; 3100 μF, 150 V; plastic tube, w/bracket.	C3, C4, C5 C6, C7 & C8
HB-17313	CHOKE.	L1
HA-7763	CONNECTOR, male.	P1
HA-17353	DIODE, silicon: 6 amp type, 1N2495.	CR1
HA-8903	FUSE, cartridge: 8 amp, 250, 3AB.	F1
HA-4109	FUSEHOLDER.	XF1
HA-9946	JACK, telephone.	J6
HA-6631	KNOB, pointer.	For S5
HA-17365	LAMP, glow: high brightness.	For I1
HA-17311	LIGHT, indicator: neon, clear (colorless) frosted back, stove-pipe plastic.	I1
HB-17352	METER	M
HA-3133	PLUG, telephone.	P4
HA-17309	PLUG, white.	P7
HA-17349	PLUG, red.	P6
HA-17350	PLUG, black.	P5
HA-17344	RECEPTACLE, box mounting: three socket inserts, solid shell.	J7
HA-12946	RECTIFIER, silicon: 600 VPI, 500 MA (F6).	CR2, CR3
HA-9904	RELAY: DPDT, coil 115 VAC.	K2
HA-10744	RELAY: DPDT w/3/16" dia. silver auxiliary contacts.	K1
H-1009-580	RESISTOR, fixed: comp; 3 meg ±5%, ½W.	R1
H-1100-19	RESISTOR, fixed: WW; 250 ohms ±10%, 100 W.	R2
H-1100-38	RESISTOR, fixed: WW; 10 ohms ±5%, 10 W.	R4

TABLE OF REPLACEABLE PARTS 2470

RFL PART NO.	NAME OF PART AND DESCRIPTION	DIAGRAM SYMBOL
HB-17340	SHUNT ASSEMBLY	R3
HA-17323	SOCKET, red.	J3
HA-17324	SOCKET, black.	J5
HA-17325	SOCKET, white.	J4
HA-3709	SWITCH, toggle: SPST, ST42A.	S1
HA-6109	SWITCH, safety door (male).	P2, P3
HA-6110	SWITCH, safety door (female).	J1, J2
HA-8735	SWITCH, push-button.	S2, S3
HA-15593	SWITCH, sensitive: SPST.	S4
HB-17308	SWITCH, rotary: 1 section, 1 pole, 7 positions.	S5
HA-1595	TUBE, Ignitron, GL415.	V1
HB-17312	TRANSFORMER, power, 150 V peak. 115V/115V, 50/60 cps.	T1
HB-17314	TRANSFORMER, power, 115V/115V, 50/60 cps, 300V peak @ 0.1 ADC.	T2
HA-9254	CONNECTOR, male. (For 230V operation).	P1
HA-7715	FUSE, cartridge: 5 amp, Slo-blo, 125 V, 3AG (For 230 V operation).	F1
MODEL 2500 BOOSTER UNIT		
HA-17344	Receptacle box mounting; Three socket inserts solid shell.	
HA-17315	Capacitor electrolytic: aluminum; 3100 μF 150 V plastic tube, w/bracket.	


P4
J6
W2
P5
BLK
P6
RED
RED
BLK
BLK
WH
RED
J5
J4
J3
R3
V1
GL-415
C8
3100
UF
C7
3100
UF
C6
3100
UF
C5
3100
UF
C4
3100
UF
C3
3100
UF
WH-YEL
RED
BLK
M
BLK
J7
A
B
C
WH-BLK
OR
R1
3 MEG
1/2 W
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R4
10
10W
BLK
BLK
BLK
RED
CR1
BLU
OR
YEL
YEL
S4
HOOD INTERLOCK
OR
PUR
BRN
K2
S3
CHARGE
GRN
YEL
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GREY
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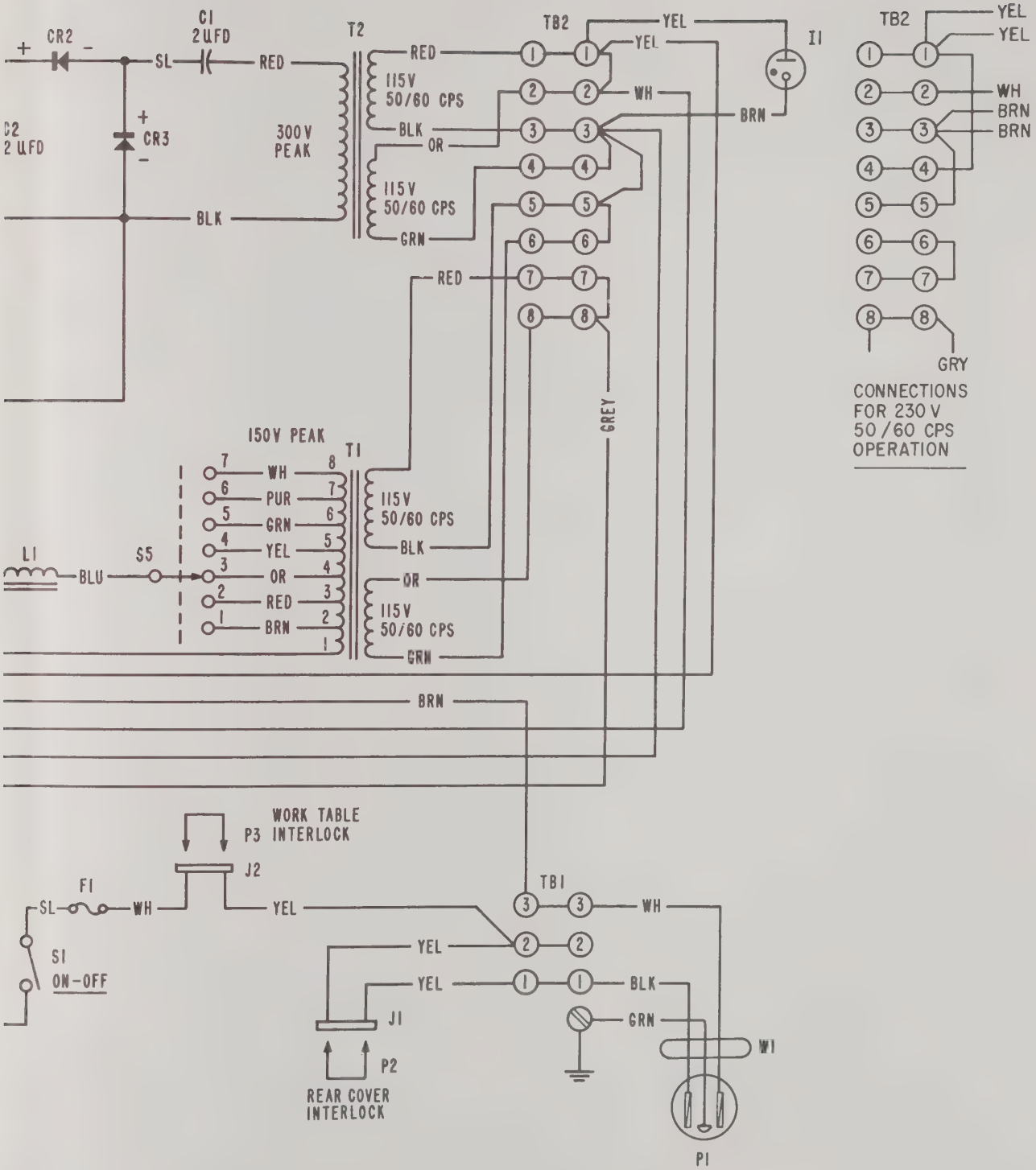

Schematic Diagram of Model 2470 Magnet Charger.

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HA-1259	CAPACITOR, fixed: oil-filled paper; 2 μF, 600 V.	C1, C2
HA-18084	CAPACITOR, electrolytic: aluminum; 1200 μF, 350 V; plastic tube, w/bracket.	C3, C4, C5, C6, C7 & C8
HB-18087	CHOKE.	L1
HA-7763	CONNECTOR, male.	P1
HA-17353	DIODE, silicon: 6 amp type, 1N2495.	CR1, CR2
HA-10758	FUSE, cartridge: 10 amp, Slo-blo, 3AG.	F1
HA-4109	FUSEHOLDER.	XF1
HA-9946	JACK, telephone.	J6
HA-6631	KNOB, pointer.	For S5
HA-17365	LAMP, glow: high brightness.	For I1
HA-17311	LIGHT, indicator: neon, clear (colorless) frosted back, stove-pipe plastic.	I1
HB-18079	METER.	M
HA-3133	PLUG, telephone.	P4
HA-17309	PLUG, white.	P7
HA-17349	PLUG, red.	P6
HA-17350	PLUG, black.	P5
HA-18085	RECEPTACLE, box mounting: three socket inserts, solid shell.	J7
HA-12946	RECTIFIER, silicon: 600 VPI, 500 MA (F6).	CR3, CR4
HA-9904	RELAY: DPDT, coil 115 VAC.	K2
HA-10744	RELAY: DPDT w/3/16" dia. silver auxiliary contacts.	K1
H-1009-580	RESISTOR, fixed: comp; 3 meg ±5%, ½ W.	R1
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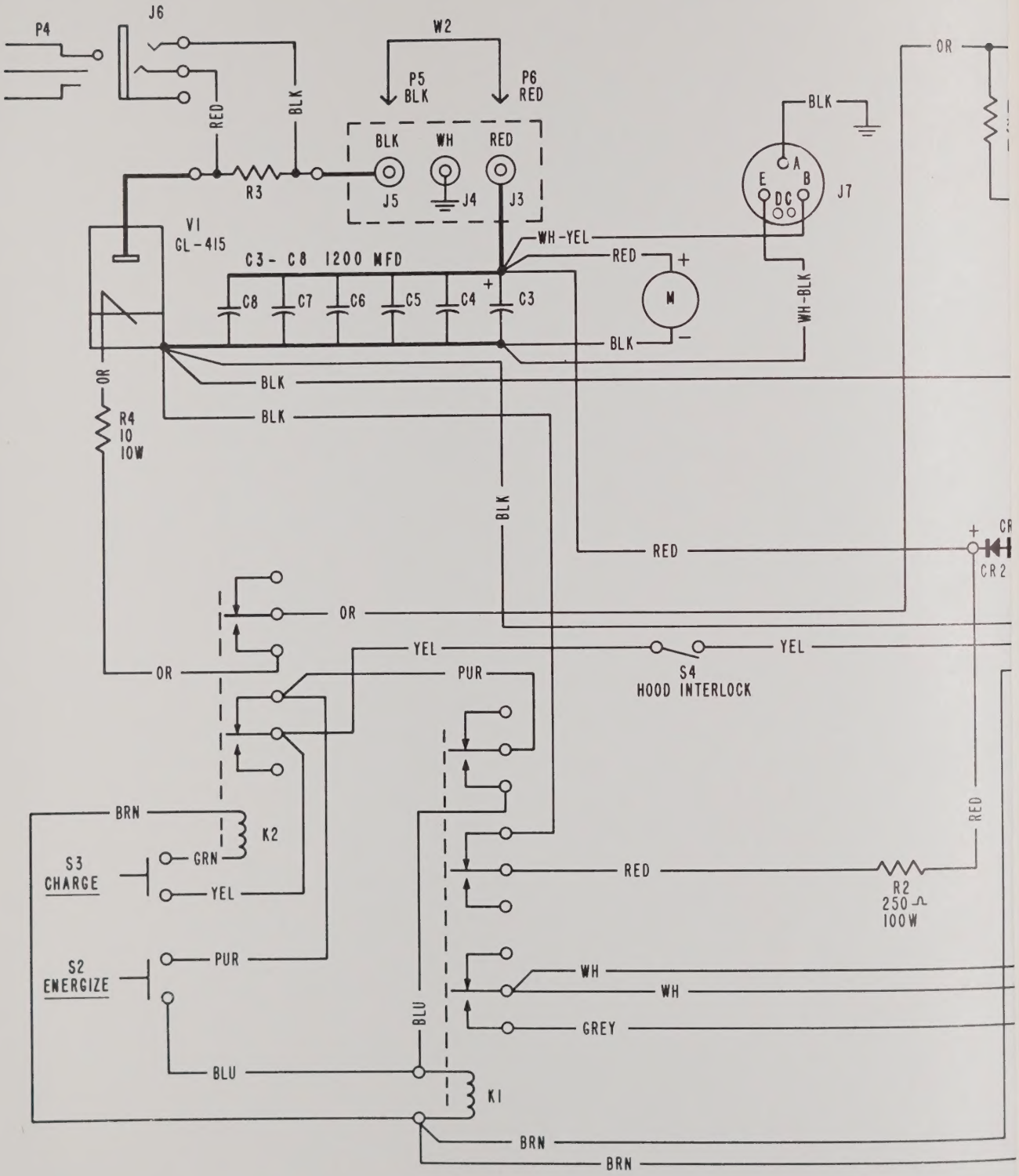
HA-17324	SOCKET, black.	J5
HA-17325	SOCKET, white.	J4
HA-3709	SWITCH, toggle: SPST, ST42A.	S1
HA-6109	SWITCH, safety door (male).	P2, P3
HA-6110	SWITCH, safety door (female).	J1, J2
HA-8735	SWITCH, push-button.	S2, S3
HA-15593	SWITCH, sensitive: SPST.	S4
HB-17308	SWITCH, rotary: 1 section, 1 pole, 7 positions.	S5
HA-1595	TUBE, Ignitron, GL415.	V1
HB-18086	TRANSFORMER, power, 340 V peak, 115V/115V, 50/60 cps.	T1
HB-17314	TRANSFORMER, power, 115V/115V, 50/60 cps, 300V peak @ 0.1 ADC.	T2
HA-9254	CONNECTOR, male. (For 230V operation).	P1
HA-7715	FUSE, cartridge: 5 amp, Slo-blo, 125 V, 3AG (For 230 V operation).	F1
MODEL 2500-350 BOOSTER UNIT		
HA-18085	Receptacle box mounting; Five socket inserts solid shell.	
HA-18084	Capacitor electrolytic: aluminum; 1200 μF 350 V; plastic tube, w/bracket.	


P4
J6
W2
P5
BLK
P6
RED
BLK
RED
BLK
WH
RED
J5
J4
J3
R3
V1
GL-415
C3 - C8 1200 MFD
C8
C7
C6
C5
C4
C3
WH-YEL
RED
M
BLK
WH-BLK
J7
A
E
B
D
C
OR
R4
10
10W
BLK
BLK
BLK
RED
CR
CR2
OR
YEL
YEL
S4
HOOD INTERLOCK
OR
PUR
BRN
K2
S3
CHARGE
GRN
YEL
RED
R2
250Ω
100W
RED
S2
ENERGIZE
PUR
WH
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GREY
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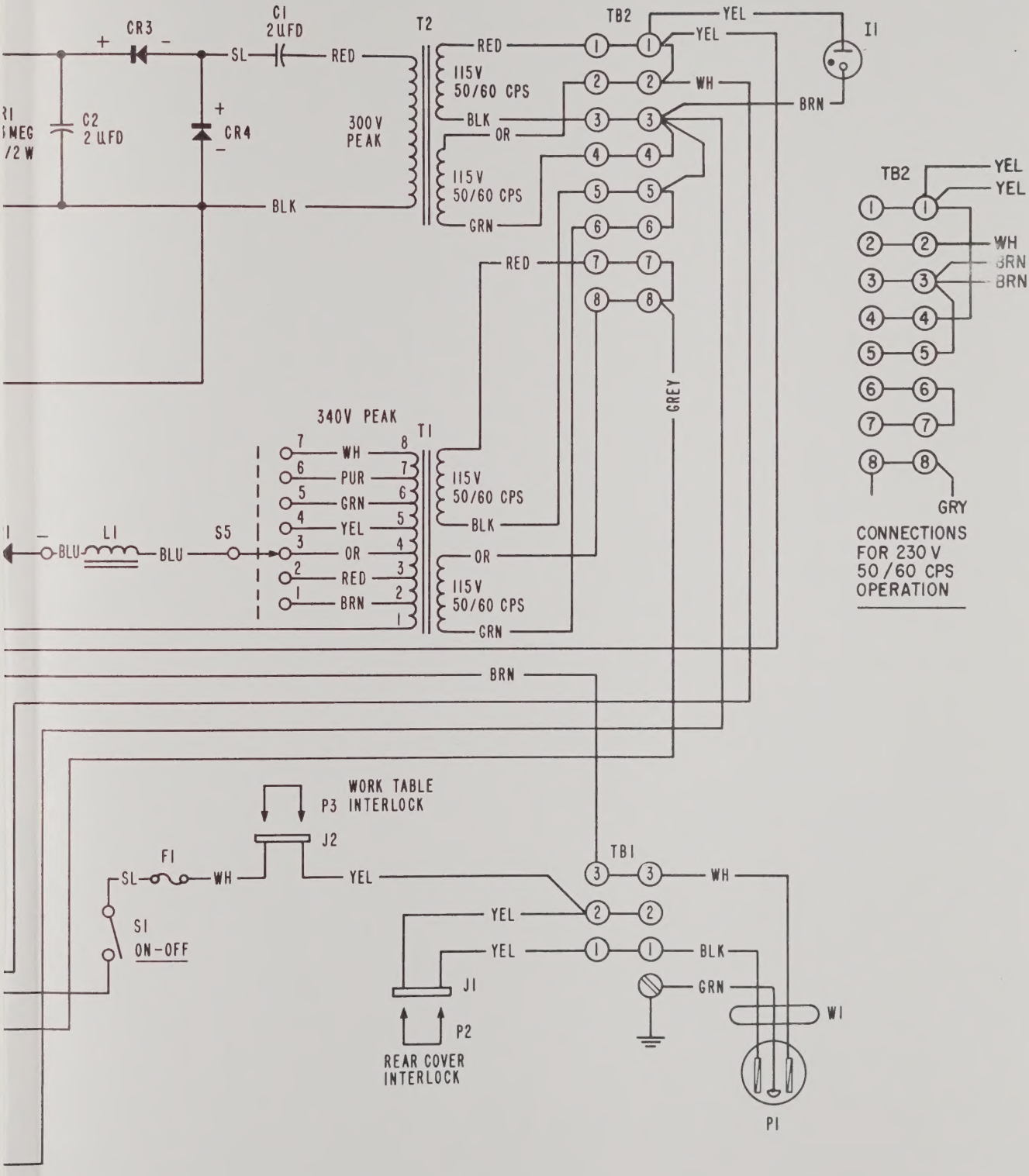
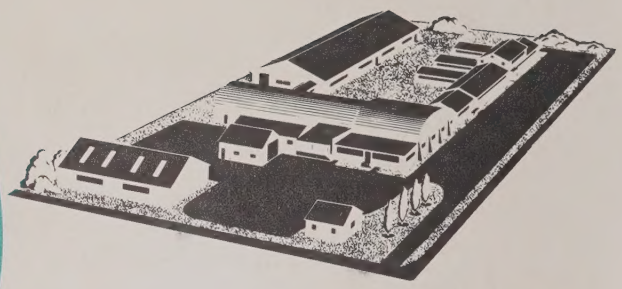
BLU
K1
BRN
BRN



Schematic Diagram of Model 2470-350 Magnet Charger.



Warranty

The Models 2470 and 2470-350 Magnet Chargers carries a warranty of 12 months from date of delivery for replacement of any part, except tubes, which fails during normal operation or service. A deficient part should be returned to the factory, shipping charges pre-paid, for replacement f. o. b. Boonton, N. J.

Radio Frequency Laboratories, Inc.
BOONTON, NEW JERSEY, U.S.A.

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